PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : D21F 11/00, 1/00 — A1

(11) International Publication Number: WO 97/32081

(43) International Publication Date: 4 September 1997 (04.09.97)

(21) International Application Number: PCT/US97/03141

(22) International Filing Date: 28 February 1997 (28.02.97)

(30) Priority Data:

60/012,696	29 February 1996 (29.02.96)	US
08/628,235	4 April 1996 (04.04.96)	US
08/733,934	18 October 1996 (18.10.96)	US

(71) Applicant: ASTEN, INC. [US/US]; 4399 Corporate Road, P.O. Box 118001, Charleston, SC 29423-8001 (US).

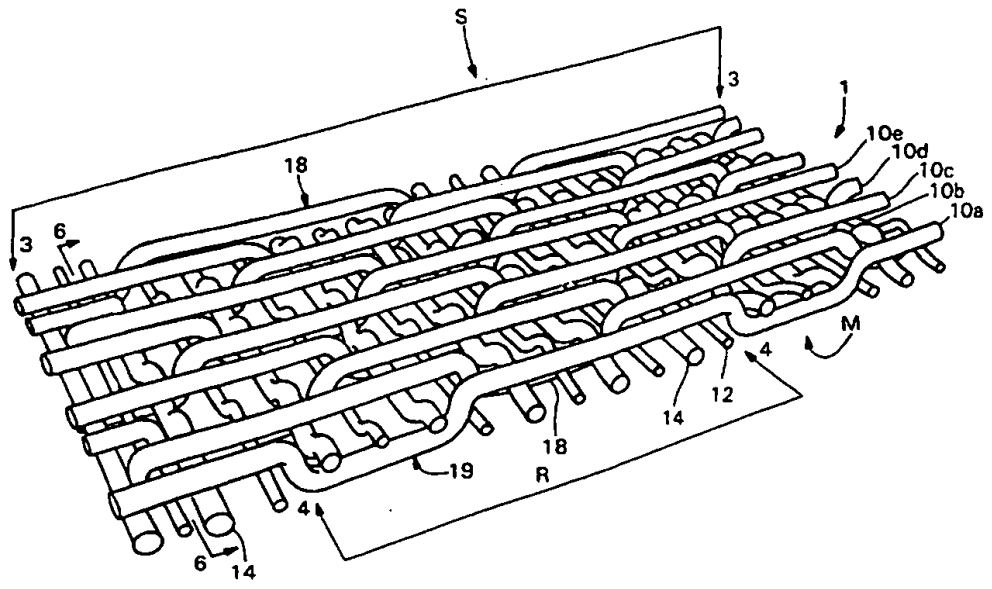
(72) Inventors: AHRENS, Frederick, W.; 43 Parkview Lane, Hortonville, WI 54944 (US). WRIGHT, Walter, P.; 5263 White Pine Drive, Larsen, WI 54947 (US). WORRY, Gary, L.; 3040 West Spencer Street, Appleton, WI 54914 (US). GULYA, Thomas, G.; 6531-338 Paces Arbor Circle, Raleigh, NC 27609 (US).

(74) Agents: VOLPE, Anthony, S. et al.; Volpe and Koenig, P.C., 400 One Penn Center, 1617 John F. Kennedy Boulevard, Philadelphia, PA 19103 (US).

(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).

Published
With international search report.

(54) Title: PAPERMAKING FABRIC, PROCESS FOR PRODUCING HIGH BULK PRODUCTS AND THE PRODUCTS PRODUCED THEREBY



(57) Abstract

The present invention generally provides a broken twill, through-air drying (TAD) fabric for use in the formation of a paper web. The present invention more particularly provides a 7,3 broken twill TAD fabric which is potentially useful in forming large areas of high bulk and absorbency in the resulting paper product.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AM	Armenia	GB	United Kingdom	MW	Malawi
AT	Austria	GE	Georgia	MX	Mexico
AU	Australia	GN	Guinea	NE	Niger
BB	Barbados	GR	Greece	NL	Netherlands
BE	Belgium	HU	Hungary	NO	Norway
BF	Burkina Faso	IE	Ireland	NZ	New Zealand
BG	Bulgaria	IT	Italy	PL	Poland
BJ	Benin	JP	Japan	PT	Portugal
BR	Brazil	KE	Kenya	RO	Romania
BY	Belarus	KG	Kyrgystan	RU	Russian Federation
CA	Canada	KP	Democratic People's Republic of Korea	SD	Sudan
CF	Central African Republic	KR	Republic of Korea	SE	Sweden
CG	Congo	KZ	Kazakhstan	SG	Singapore
CH	Switzerland	LI	Liechtenstein	SI	Slovenia
CI	Côte d'Ivoire	LK	Sri Lanka	SK	Slovakia
CM	Cameroon	LR	Liberia	SN	Senegal
CN	China	LT	Lithuania	SZ	Swaziland
CS	Czechoslovakia	LU	Luxembourg	TD	Chad
CZ	Czech Republic	LV	Latvia	TG	Togo
DE	Germany	MC	Monaco	TJ	Tajikistan
DK	Denmark	MD	Republic of Moldova	TT	Trinidad and Tobago
EE	Estonia	MG	Madagascar	UA	Ukraine
ES	Spain	ML	Mali	UG	Uganda
FI	Finland	MN	Mongolia	US	United States of America
FR	France	MR	Mauritania	UZ	Uzbekistan
GA	Gabon			VN	Viet Nam

PAPERMAKING FABRIC, PROCESS FOR PRODUCING HIGH BULK PRODUCTS AND THE PRODUCTS PRODUCED THEREBY

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to a fabric for use in a through-air drying (TAD) process for producing a high bulk, absorbent paper product.

BACKGROUND OF THE INVENTION

The physical attributes of a paper web are controlled not only by the web fibers, but also by the fabric on which the web is produced. The TAD fabric that is used to support the web and to form an impression in the web plays a central role in the development of the product attributes. The fabric character also has a significant effect on processing attributes such as runnability and productivity.

In a TAD process, the sheet side of the fabric refers to that side of the fabric which is generally used to contact the aqueous wet web. The back side refers to the side of the fabric which generally does not contact the web.

A variety of types of TAD fabrics have been proposed in an attempt to achieve good product attributes and processing efficiency. Early TAD fabrics were primarily single layer, plain weave, semi-twill, 4-shed or 5-shed fabrics. U.S. Patent No. 3,301,746 disclosed the use of square, diagonal twill and semi-twill weaves. U.S. Patent No. 3,974,025 disclosed the use of the back side of a semi-twill TAD fabric. Another early development in TAD fabric technology is disclosed in U.S. Patent No. 4,239,065 to Trokhan. This patent discloses specific

weaves wherein the top-surface crossovers define a bilaterally staggered array of wicker-basket-like cavities where each cavity spans at least one sub-top-crossover.

TAD fabrics create bulk in a fibrous web by compacting the web only along related raised areas. Large portions of the fibrous web in the open areas or baskets between the raised areas are not compressed during the TAD process. These uncompressed areas are not only soft and absorbent but are higher in bulk. Single layer woven fabrics have the advantages that they are inexpensive and efficient without creating difficult processing problems. However, these fabrics have the drawback that as the open areas are made larger, i.e., the size of the baskets which form non-compressed areas of the fibrous web are increased, these fabrics provide insufficient support of the fibrous web. Lack of web support causes pinhole formation in the web, fiber bleed-through at the vacuum boxes, and air channeling, reducing both vacuum dewatering efficiency and TAD drying efficiency. Pinholing may negatively impact paper attributes including strength and visual appearance.

The present invention provides a woven fabric with sufficiently large open area to produce a soft, bulky paper web without the formation of pinholes, fiber bleed-through at the vacuum boxes or air channeling problems. Furthermore, the present invention addresses these advantages in a single layer fabric.

SUMMARY OF THE INVENTION

It is also an object of the present invention to provide a through air drying fabric which is simple and inexpensive yet which produces a bulky and absorbent paper sheet.

It is further an object of the present invention to provide a fabric which reduces fiber bleed through and the occurrence of pin holes.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is an illustration of a process for forming a paper web using a through air dryer paper machine.

Figure 2 is a perspective view of a preferred embodiment of a papermaking fabric in accordance with the present invention.

Figure 3 is a top plan view of the papermaking fabric taken along line 3-3 in **Figure 2**.

Figure 4 is a side elevation of the papermaking fabric taken along line 4-4 in **Figure 3**.

Figure 5a-e is a series of diagrammatic views illustrating the MD yarn weave pattern for the papermaking fabric of **Figure 2**.

Figure 6 is a side perspective view of the papermaking fabric taken along line 6-6 in **Figure 2**.

Figure 7 is a side elevation view of the papermaking fabric taken along line 7-7 in **Figure 6**.

Figure 8a-b is a series of diagrammatic views illustrating the smaller and larger diameter CD yarn weave patterns for the papermaking fabric of Figure 2.

Figure 9 is a top plan view of an alternate embodiment of the papermaking fabric of **Figure 2**.

Figure 10 is an illustration of the fabric knuckles and baskets which are used to impress the paper web according to the present invention.

DETAILED DESCRIPTION

The present invention is directed to a fabric for making a soft, high bulk and absorbency web. As illustrated in the TAD process of **Figure 1**, a web is formed on a forming structure **(180)** from a liquid slurry of pulp. The pulp is introduced from a headbox **(10)** to the forming structure. The forming structure can be a twin wire former, a crescent former or any art recognized forming configuration. The web is ultimately transferred from the forming structure to a carrier fabric which is a TAD impression fabric.

Referring to **Figures 2-4**, fabric **1** is shown in a 7/3 broken twill weave in accordance with the teachings of the present invention. Machine direction filaments(MD) **10** are interwoven with a system of alternating smaller and larger diameter cross direction filaments (CD) **12, 14**. The fabric has a sheet side S, see **Figure 3**, and a machine side M, not separately illustrated, with the sheet side of fabric **1** defining the paper characteristics.

Figures 5a-e further illustrate the weave repeat R of **Figure 2**. Each MD filament 10 weaves over seven, and under three CD filaments **12, 14**. Under each sheet side MD float **18** there are four smaller diameter CD filaments **12** and three

larger diameter CD filaments **14**. The smaller diameter CD filaments **12** are positioned on each side of each larger diameter CD filament **14**. Over each machine side MD float **19** there are one smaller diameter CD filament **12** and two larger diameter CD filaments **14**. The smaller diameter CD filament **12** is parallel to and between the two larger diameter CD filaments **14**. These relationships should be maintained in any weave variations from the above described weave.

As shown in **Figures 6-8**, the smaller diameter CD filament **12** weaves with the MD filaments **10** in a repeat pattern of over one and under four. The larger diameter CD filament **14** weaves with the MD filaments **10** in a repeat pattern of over one, under one, over one, under two. Since the CD repeat lengths relative to the MD yarns **10** are equal, each sheet side knuckle **13** formed by a smaller diameter CD filament **12** is adjacent to and between a pair of sheet side knuckles **15** formed by the larger diameter CD filaments **14**. Since the MD filaments **10** are in a relatively higher plane than the smaller diameter CD filaments **12** and float over a number of CD filaments **14**, the MD floats **18** dominate the sheet side S of the fabric **1**. These higher profile MD floats **18** cause compression in the paper sheet (not shown) when it is on fabric **1**.

The combination of the long sheet side MD floats **18** and knuckles of CD filaments **14** forms a rim around the basket-like depressions in the sheet side of fabric **1**. The lower plane knuckles of CD filaments **12** do not interfere with the baskets where they appear and the long machine side floats of the CD filaments **12** provide a lower support or base for the fibers.

The paper fibers in these basket forms are relatively uncompressed in comparison to the fibers in contact with the MD floats **18** and CD knuckles **15**.

Each basket is defined by at least two MD filaments **10** on two sides and two larger diameter CD filaments **14** on the remaining two sides. The compression areas on the sheet side of the fabric are aligned in the CD direction and are staggered in the MD direction thereby forming diagonally aligned baskets along the length of the fabric **1**. The pattern of the weave causes larger and smaller baskets to form. In a single CD line of baskets, the CD length of the baskets alternates. If the shorter basket is deemed of length 1 then the longer basket is approximately of length 1-1/2. The shorter basket also has slightly less MD length and caliper than the longer baskets. These baskets are illustrated by the darkened areas **26** and **28** in **Figure 10**.

As shown in **Figures 6, 8a and 8b**, the smaller diameter CD filaments **12** are predominately in the lower portion of the fabric **1** and provide additional support for uncompressed nubs **12** that allow a paper sheet, not shown, to imprint deeply on fabric **1** without fiber bleed through or hole formation. In addition, the location of the smaller diameter CD filaments **12** in the lower portion of the fabric provides the desired additional fiber support without unduly blocking the drainage holes **16**, see **Figure 3**, in fabric **1**.

In an alternate embodiment of the present invention, shown in **Figure 9**, the fabric **2** is surfaced to increase the contact area and provide a more monoplane sheet side. The fabric **2** is

surfaced until the larger diameter CD filaments **14** are reached at **24**. Surfacing of MD and CD filaments **10** and **14** causes additional sheet contact on the added surface area that compresses fibers while the baskets between the surfaced floats **21** and knuckles **24** create areas of uncompressed paper fibers. Large **28** and small **26** baskets are shown by the darkened areas in **Figure 10**.

In either embodiment the MD and CD filaments may be polyester, polyamide, vinyl, acrylic, nylon, or other materials as known in the art. In a preferred embodiment of the present invention, the filaments are made of polyester which has been treated for hydrolysis resistance. The MD filaments and CD filaments need not be of the same material. The smaller diameter CD filaments may also differ in composition from the larger MD and CD filaments. For example, hollow, compressible yarns may be utilized instead of solid filaments for the smaller diameter CD filaments. Hollow yarns will provide additional resiliency and compressibility to the fabric. Suitable yarns are described in U.S. Patent No. 5,368,696 which is incorporated by reference as if fully set forth herein. Preferably, the hollow core of the yarns have a void range of fifteen to thirty percent (15%-30%).

In the preferred embodiment the larger diameter CD filaments **14** range between about 0.3 to 0.6 mm and preferably about 0.4 to 0.5mm. The smaller diameter CD filaments **2** range between about 0.15 and about 0.3 mm and preferably about 0.2 mm. Preferably, the diameter of the larger CD yarns is at least equal to the diameter of the MD yarns.

In a preferred embodiment of the present invention, the fabric as woven achieves an air permeability in the range of 600 to 800 CFM and most preferably about 700 CFM, as tested on a Frazier air permeability tester. The fabric of the present invention preferably has an open area, as seen in **Figure 3**, in the range of ten to twenty-five percent (10%-25%), and most preferably about 20.0 percent (20.0%).

The MD filaments and the larger CD filaments are preferably monofilaments. The smaller CD yarn or filament may be of any configuration, for example, monofilament, multi-filament cable, flat monofilament or flat monofilament with holes therethrough, as will be understood by the skilled artisan.

The ratio of the larger diameter CD filaments to the smaller CD filaments diameter is preferably 1.5:1 to 4:1, more preferably 2:1.

The fabric of the present invention may be woven in an endless configuration or may be woven flat. The description set forth in the present specification is based upon a fabric that has been woven flat with the warp filaments running in the machine direction. It will be apparent to the skilled artisan that the machine direction and cross machine direction yarns may be reorientated for an endless weaving process.

The fabric according to one embodiment of the present invention has a mesh count of 20 to 50 filaments per inch of cross direction distance, more preferably 30 to 40 filaments per inch of cross direction distance. The fabric according to one embodiment of the present invention has a mesh count

sufficient to prevent pinholing of the fibrous web. It is presently preferred that the mesh count be no less than 20. The fabric according to one embodiment of the present invention has a mesh count of 20 to 50 filaments per inch of machine direction distance, more preferably at least 30 filaments per inch of machine direction distance.

The fabric of the present invention may be further treated to improve the contact area thereof. Any art recognized method for increasing contact area can be used. Exemplary methods are described in U.S. Patent No. 3,579,164, which issued March 30, 1971, to Friedberg et al. This patent discloses surfacing or abrading the high points of strand crossovers to provide flat surfaced regions. Contact area refers to the amount of fabric surfacing. The fabric of the present invention preferably has a contact area in the range of 20% to 40%, more preferably 25 to 35%, and most preferably about 30%.

The fabric of the present invention may also be described in terms of orientation of the open areas or baskets and contact areas of floats or knuckles. The fabric of the present invention has alternating large and small basket sizes. Basket and nub sizes are measured at the maximum point between two sides and all measurements are based upon the fabric prior to treatments such as abrading to increase contact area. The larger baskets and nubs are larger than about 40 mils by 40 mils, more preferably in the range of about 60 mils by 40 mils to about 120 mils by 100 mils, most preferably about 80 mils by 50 mils. The smaller baskets and nubs are larger than about 20 mils by 30 mils. The baskets also have different depths and

thus the corresponding nubs have different heights. The large baskets are preferably about 0.3 to 0.7 mm deep, more preferably about 0.3 to 0.5 mm deep and most preferably about 0.4 mm deep. The smaller baskets are preferably about 0.15 to 0.4 mm deep, more preferably about 0.2 to 0.3 mm deep, and most preferably about 0.25 mm deep. The baskets are tri-directionally aligned. The large and small baskets are aligned in the cross direction and the large and small baskets are each aligned in both diagonal directions.

The fabric as described herein is used preferably in the TAD with the long warp knuckles on the sheet side.

A test fabric was woven using PET monofilaments which had been treated to render them hydrolysis resistant. The large diameter monofilaments were 0.4 mm. The smaller diameter filaments were 0.2 mm. The fabric was woven using all large diameter monofilaments in the machine direction and alternating large and small diameter filaments in the cross direction.

The large diameter MD filaments and large diameter CD filaments were interwoven to create a 7,3 broken twill fabric. The alternating CD filaments were only interwoven to the extent necessary to secure them for support of the fibers. The mesh count for the fabric produced was 35 machine direction filaments per inch and 46 cross direction filaments per inch.

The woven fabric was treated to impart heat and dimensional stability. The fabric was further treated by sanding the MD knuckles to increase the contact area of the web to 28%.

The fabric was then seamed by the known technique by fraying out the ends and backweaving them into the fabric body to form a continuous or endless fabric.

We Claim:

1. A papermaker's fabric for forming and transporting an aqueous paper web comprising:

a single layer fabric having machine direction filaments of a first diameter and cross direction filaments of a second diameter which are interwoven to form a pattern of knuckles and baskets;

said fabric further having third diameter cross direction filaments which alternate with the second diameter cross direction filaments and form central support members at the bottom of said baskets.

2. The papermaker's fabric of claim 1, wherein each machine direction filament is woven over seven cross direction filaments and wherein three of said seven cross direction filaments are of a second diameter and four of said seven cross direction filaments are of a third diameter.

3. The papermaker's fabric of claim 1, wherein each machine direction filament is woven under three cross direction filaments, wherein two of said three cross direction filaments are of a second diameter and one of said three cross direction filaments is of a third diameter.

4. The papermaker's fabric of claim 1, wherein the first diameter machine direction filaments and the second diameter cross direction filaments are of an equal diameter.

5. The papermaker's fabric of claim 1, wherein the machine direction filaments and the cross direction filaments are all monofilaments.

6. The papermaker's fabric of claim 1, wherein the fabric has a mesh count in the cross direction of from 20 to 50 filaments per inch.

7. The papermaker's fabric of claim 1, wherein the fabric has a mesh count in the machine direction of from 20 to 50 filaments per inch.

8. The papermaker's fabric of claim 1, wherein the fabric is sanded on the sheet side.

9. The papermaker's fabric of claim 8, wherein the fabric is sanded to a contact area of 20 to 40%.

10. The papermaker's fabric of claim 1, wherein the fabric is a forming fabric.

11. In combination with a papermaking through air dryer apparatus having at least one through-dryer position, a through-dryer papermaking fabric comprising:

a single layer fabric having machine direction filaments of a first diameter and cross machine filaments of a second diameter which are interwoven to form a pattern of knuckles and basket;

said fabric having a third diameter cross direction filaments which alternate with the second diameter cross direction filaments and form substantially centrally located support members at the bottom of said baskets.

12. A papermaking fabric having a sheet side and a machine side comprised of:

a system of MD filaments selectively interwoven with a system of CD filaments having at least two subsets of smaller and larger filaments, the MD filaments forming sheet side floats in the MD direction that have a minimum length of seven CD system filaments, and the smaller CD filaments forming machine side floats in the CD direction that have a minimum length of four MD system filaments whereby the weave forms a plurality of basket-like depressions in the sheet side of the fabric.

13. The fabric of claim 12, wherein the smaller CD filaments weave in a repeat pattern of under four, over one MD filament.

14. The fabric of claim 12, wherein the larger CD filament weaves in a repeat pattern of over one, under one, over one, under two MD filaments.

15. The fabric of claim 12, wherein the knuckles formed by the smaller diameter CD filaments coincide with the knuckles of the larger diameter CD filaments.

16. The fabric of claim 15, wherein the smaller CD filaments weave in a repeat pattern of under four MD filaments, over one MD filament.

17. A papermaking fabric having a sheet side and a machine side comprised of:

a system of MD filaments selectively interwoven with a system of CD filaments, the MD filaments forming sheet side floats in the MD direction that have a minimum float of seven CD system filaments;

the CD filaments having at least two susbsets of filaments that have larger and smaller diameter filaments;

the larger diameter CD filaments define only knuckles on the sheet side; and

the smaller diameter CD filaments define only sheet side knuckles and machine side floats;

whereby the weave forms a plurality of depressions in the sheet side of the fabric.

18. The fabric of claim 17, wherein the knuckles formed by the smaller diameter CD filaments coincide with knuckles formed by the larger diameter CD filaments.

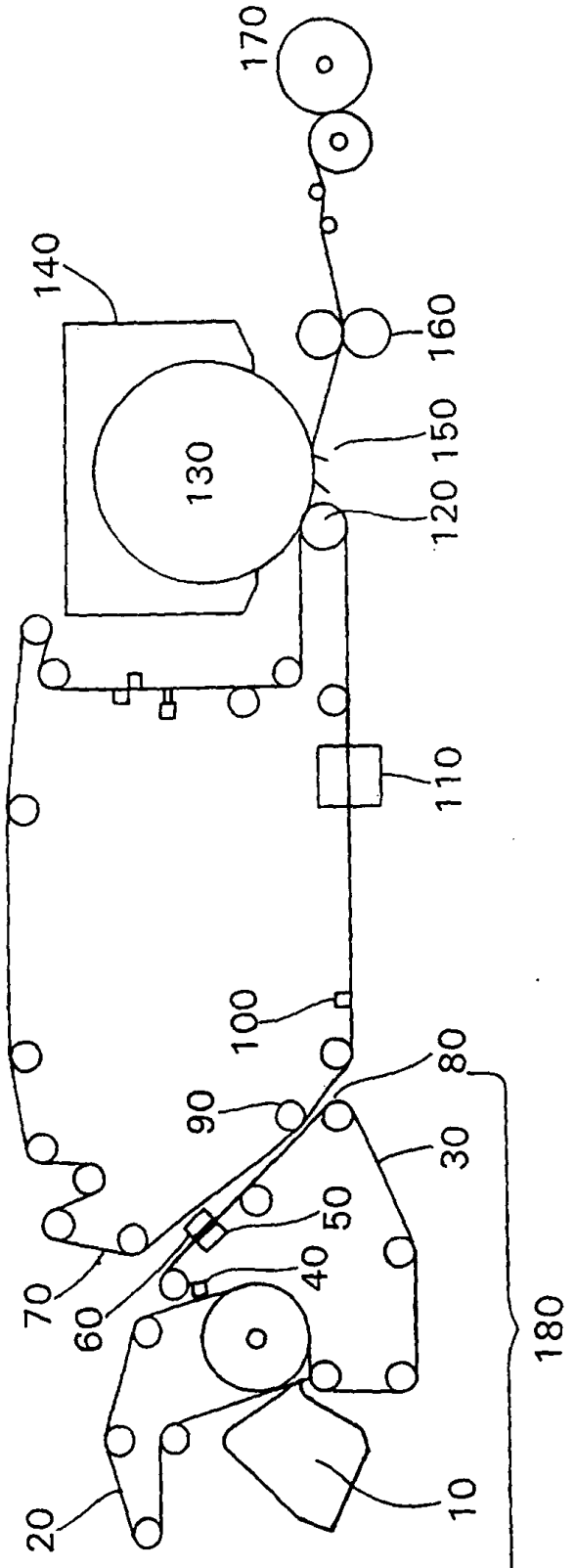


Fig. 1

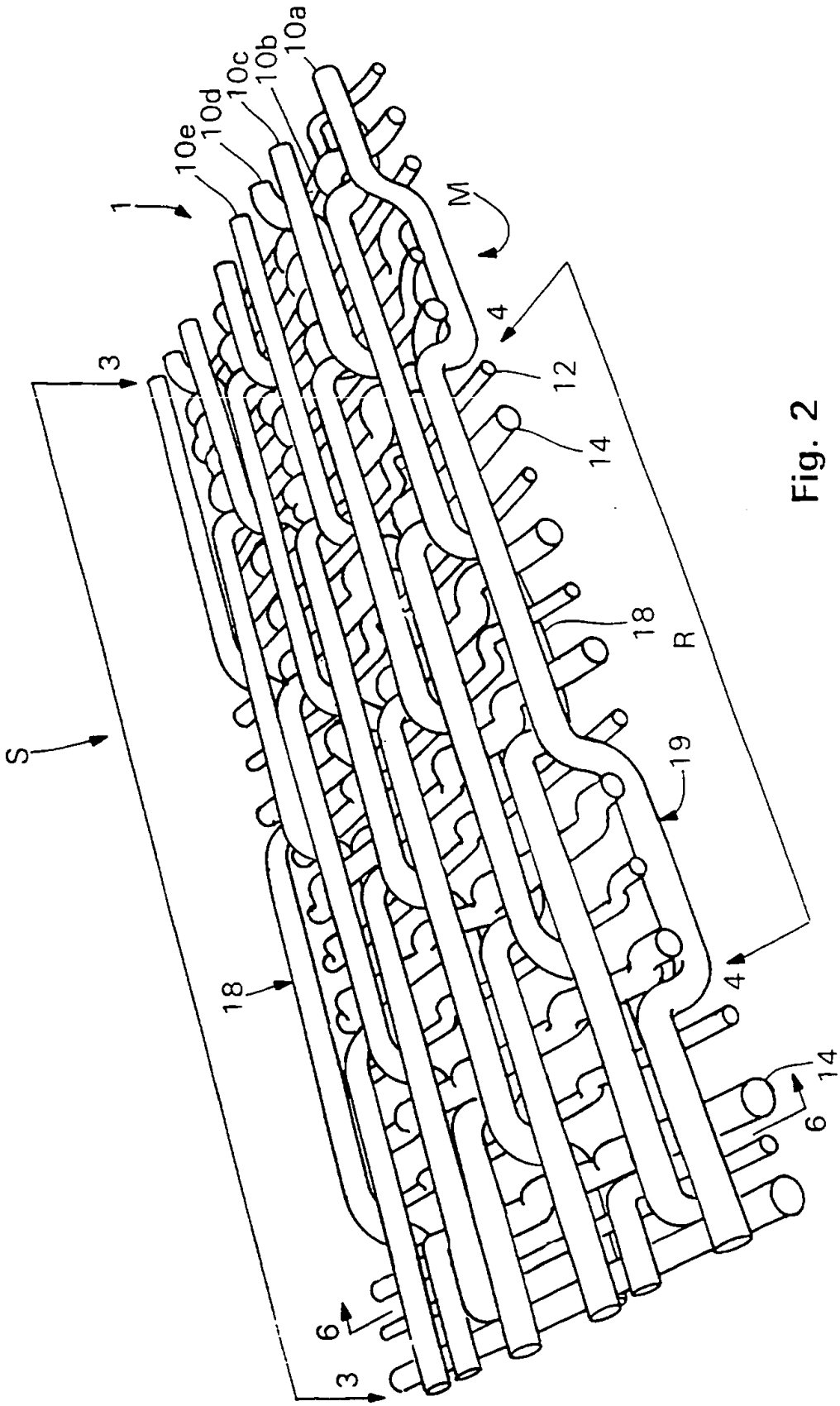


Fig. 2

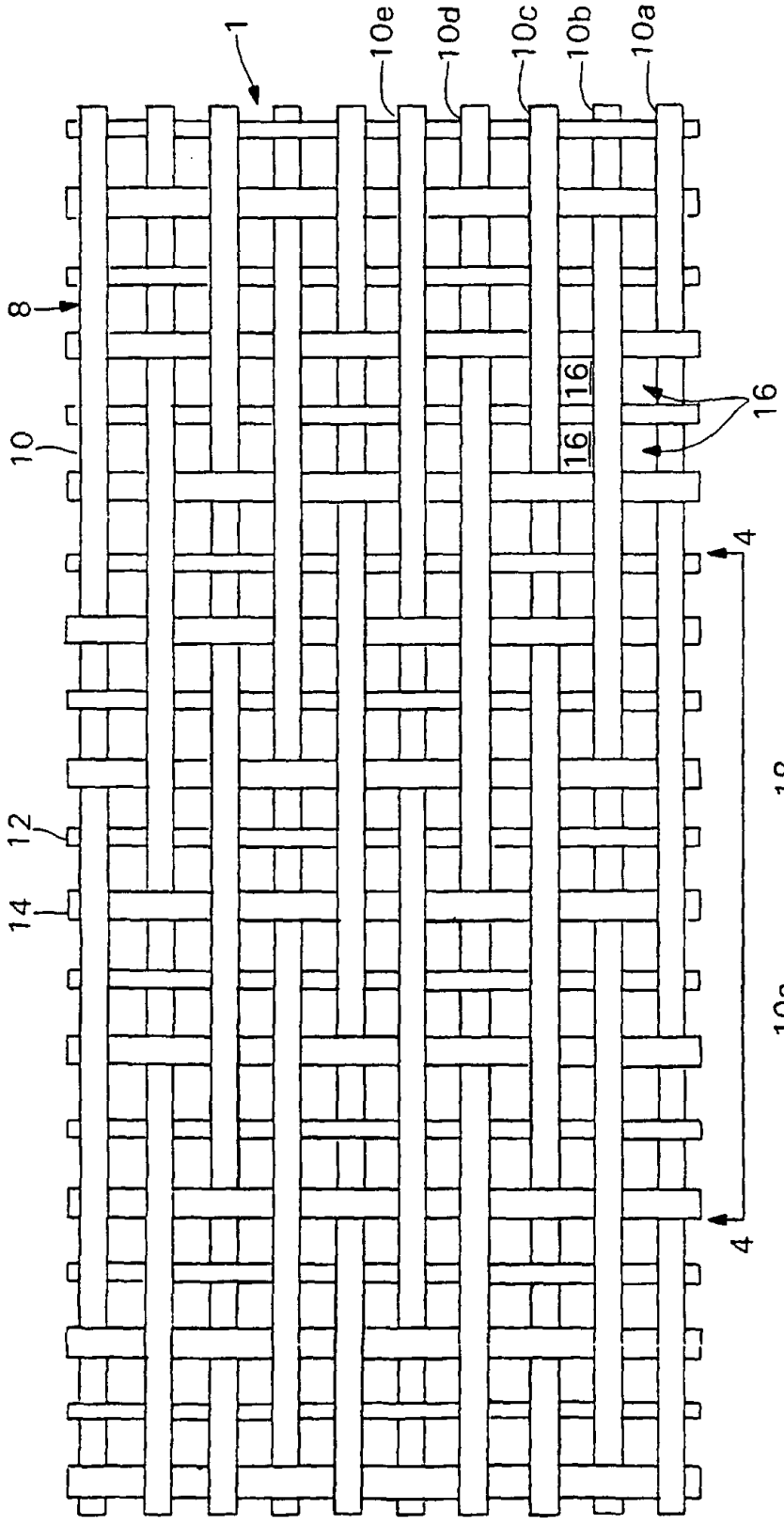


Fig. 3

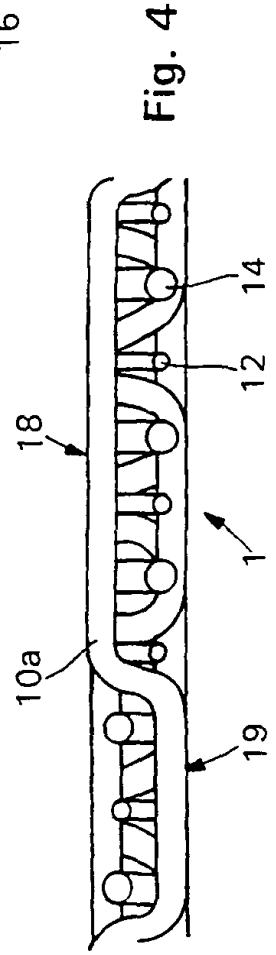


Fig. 4

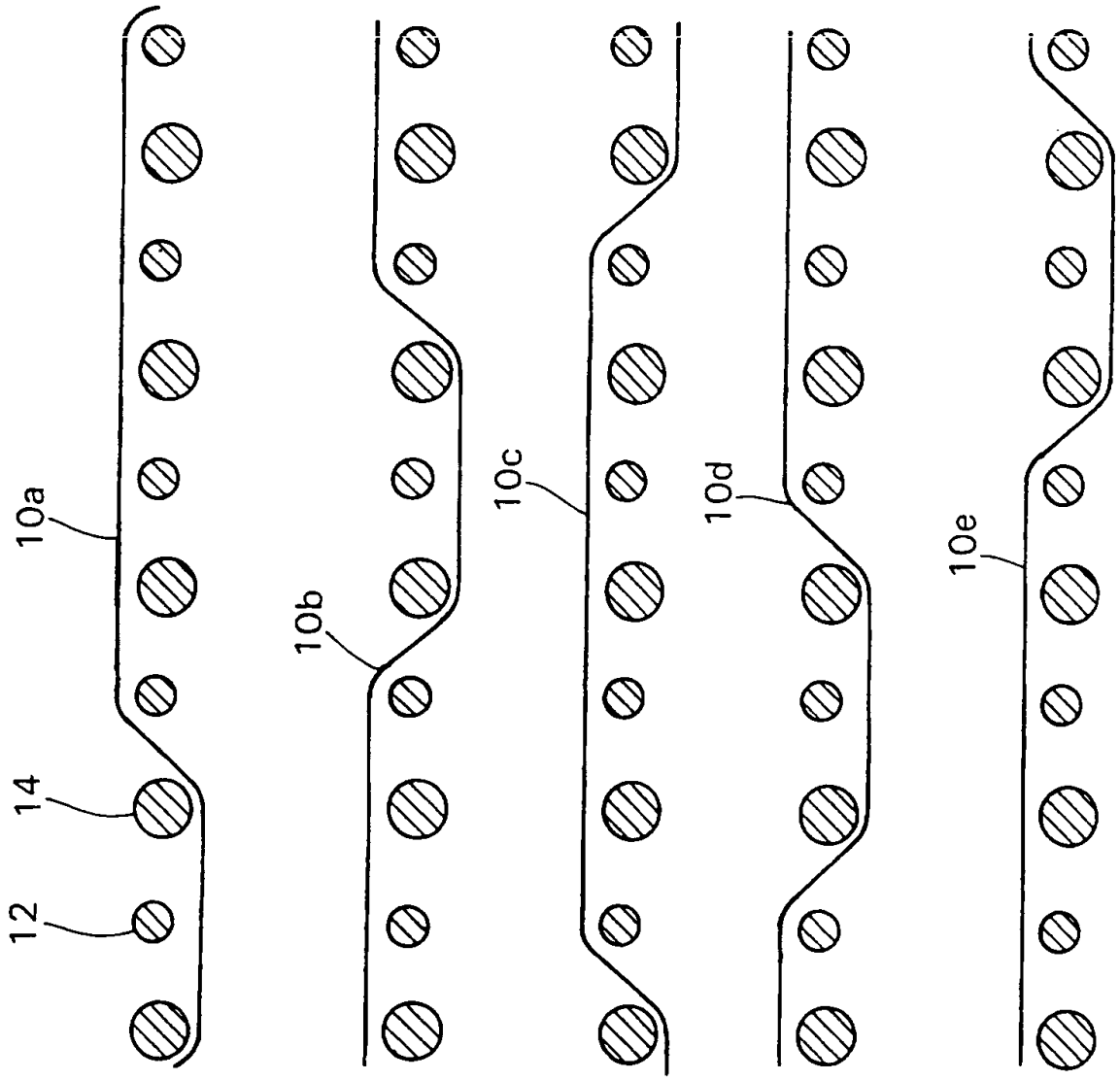


Fig. 5a
10a
14
12
Fig. 5b
10b
Fig. 5c
10c
Fig. 5d
10d
Fig. 5e
10e

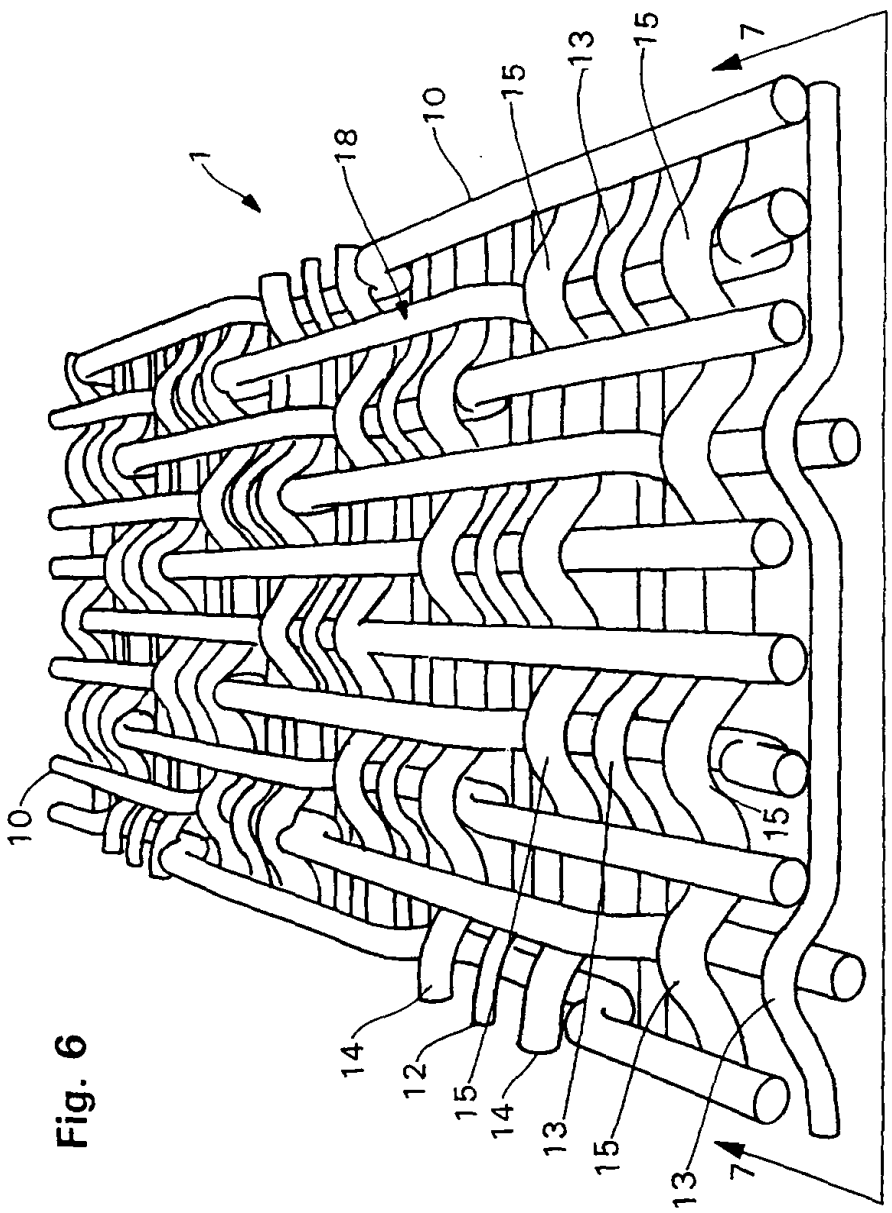


Fig. 6

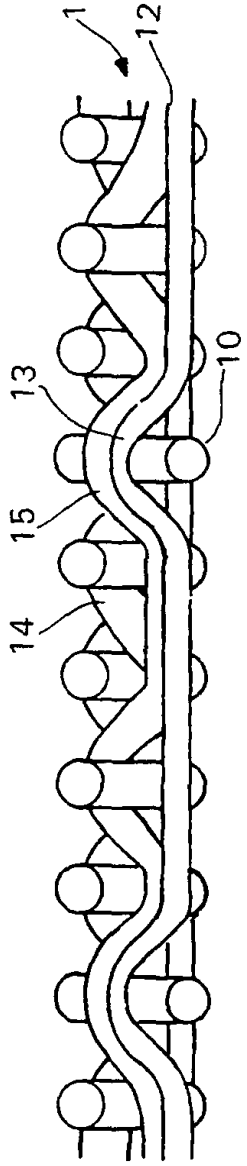


Fig. 7

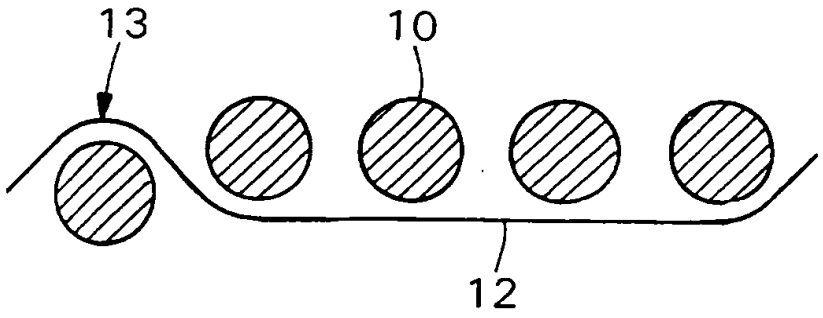


Fig. 8a

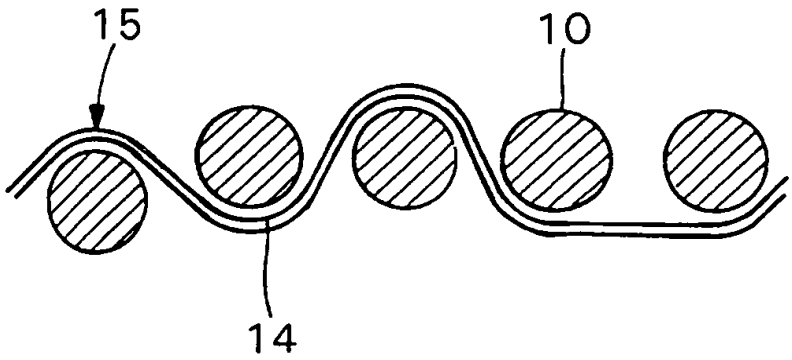


Fig. 8b

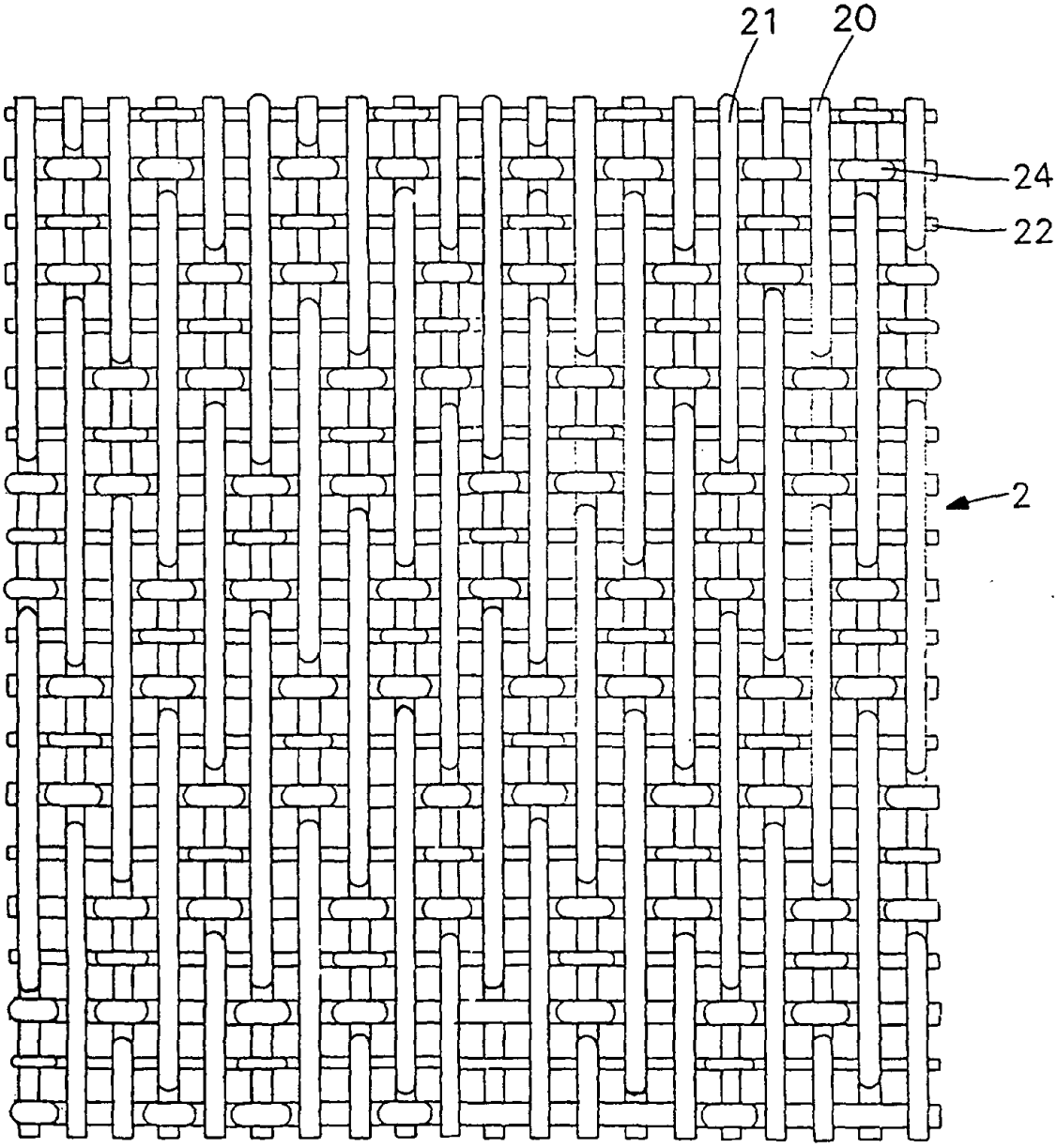


Fig. 9

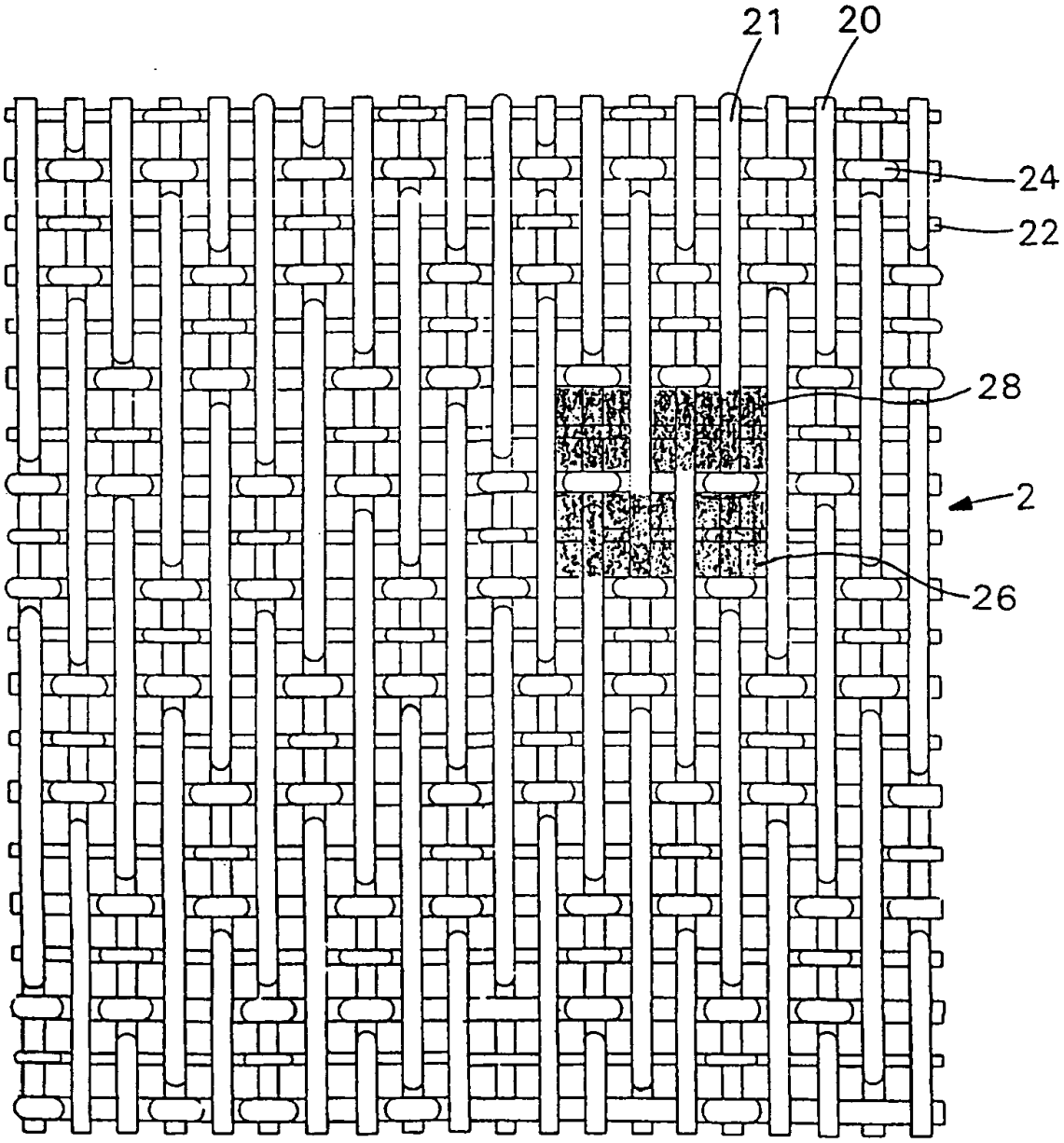


Fig. 10

INTERNATIONAL SEARCH REPORT

Inte nal Application No
PCT/US 97/03141

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D21F11/00 D21F1/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D21F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US 4 281 688 A (KELLY BRENDAN W ET AL) 4 August 1981 see column 2, line 51 - column 2, line 68; figures 7,8	1,5-7,10 8,9
X	US 5 456 293 A (OSTERMAYER VOLKER ET AL) 10 October 1995 see column 1, line 62 - column 2, line 43; figure 1	1,5,10
Y	US 3 573 164 A (FRIEDBERG NORMAN D ET AL) 30 March 1971 cited in the application see column 2, line 53 - column 2, line 56; claim 1	8,9
	-/--	

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

1

Date of the actual completion of the international search	Date of mailing of the international search report
2 June 1997	11. 06. 97
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+ 31-70) 340-2040, Tx. 31 651 epo nl, Fax (+ 31-70) 340-3016	**Authorized officer** Guisan, T

Form PCT/ISA/210 (second sheet) (July 1992)

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 191 609 A (TROKHAN PAUL D) 4 March 1980 see figures 15,16	2,12,13, 17

INTERNATIONAL SEARCH REPORT

...formation on patent family members

Inter ...al Application No
PCT/US 97/03141

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 4281688 A	04-08-81	CA 1127047 A	06-07-82
US 5456293 A	10-10-95	AU 3209495 A	04-03-96
		EP 0721517 A	17-07-96
		WO 9604418 A	15-02-96
		US 5542455 A	06-08-96
US 3573164 A	30-03-71	NONE	
US 4191609 A	04-03-80	AT 11063 T	15-01-85
		AU 528024 B	31-03-83
		AU 5626480 A	11-09-80
		CA 1124121 A	25-05-82
		EP 0015609 A	17-09-80
		JP 1002720 B	18-01-89
		JP 1524842 C	12-10-89
		JP 56031100 A	28-03-81